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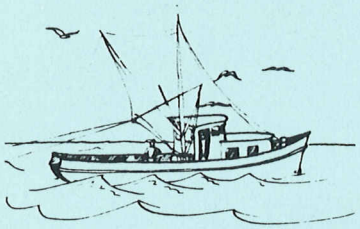

Vessel Operating Behavior in the Gulf of Mexico Shrimp Fishery: An Annotated Bibliography

by:

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November 1988

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U.S. Department of Commerce
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National Oceanic and Atmospheric Administration
William E. Evans, Administrator

National Marine Fisheries Service
James W. Brennan, Assistant Administrator for Fisheries

November 1988

Notice

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Grant, W.E. and W.L. Griffin (1979). "A bioeconomic model of the Gulf of Mexico shrimp fishery." Transactions of the American Fisheries Society, 108(1):1-13. 6

Grant, W.E., K.G. Isakson, and W.L. Griffin (1981). "A general bioeconomic simulation model for annual crop marine fisheries." Ecological Modelling, 13:195-219. 6

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Hilborn, R. (1985). "Fleet dynamics and individual variation: why some people catch more fish than others." Can. J. Fish. Aquat. Sci. 42:2-13. 7

Karpoff, J.M. (1985). "Time, capital intensity, and the cost of fishing effort." Western Journal of Agricultural Economics, 10(2):254-258. 8

Krauthamer, J.T., W.E. Grant, and W.L. Griffin (1984). "Characteristics of the Texas shrimp fleet, 1979-82." Marine Fisheries Review, 46(2):53-59. 8

Lane, D.E. (1986). "A partially observable model of decision making by fishermen." Working Paper 86-46. University of Ottawa, Ontario, Canada. 9

Lane, D.E. (1987). "Investment decision making by fishermen." Working Paper 87-20, University of Ottawa, Ontario, Canada. 9

McKelvey, R. (1983). "The fishery in a fluctuating environment: coexistence of specialist and generalist fishing vessels in a multipurpose fleet." JEEM, 10:287-309. 10

Meuriot, Eric (1986). "Fishing fleet replacement: the French policy from 1945 - 1983." Marine Policy, 10(4):294-309. 10

Orth, Geoffry C. (1986). "Fishing strategies among southeast Alaskan salmon seiners." Unpublished Master's thesis. Department of Anthropology, University of Alaska, Fairbanks, AK 99775. 10

Paterson, D.G. and J. Wilen (1977). "Depletion and diplomacy: the North Pacific seal hunt." Research in Economic History, 2:81-139. 11

Penson, John B., Jr., Ernest O. Tetty, and Wade L. Griffin (1987). "An econometric analysis of net investment in Gulf shrimp fishing vessels." Technical Article No. TA-20803 of the Texas Agricultural Experiment Station, Texas A&M University. 11

Prochaska, F.J. (1985). "Shrimp mariculture and imports: effects on U.S. markets and research needs." Presented at the Miami Economics Workshop, Sept., 6 pages. 11

Prochaska, F.J. and C.M. Adams (1987). "Analysis of U.S. shrimp prices at exvessel, wholesale, and retail market levels." Draft report, Dept. of Food and Resource Economics, University of Florida. 17 pages. 12

Prochaska, F.J. and C.O. Andrew (1974). "Shrimp processing in the southeast: supply problems and structural change." Southern Journal of Agricultural Economics, July:247-252. 12

Prochaska, F.J. and J.C. Cato (1981). "Economic conditions in the Gulf of Mexico shrimp industry: 1960 - 1981." Staff Paper 180, Food and Resource Economics Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville. April. 19 pages. 12

Prochaska, F.J. and W.R. Keithly (1984). "Market impacts of U.S. shrimp imports." Draft, University of Florida, Department of Agricultural Economics, Gainesville, Fl. 13

Prochaska, F.J., M. Suazo, and W.R. Keithly (1983). "World shrimp production trends and the U.S. import market." Tropical and Subtropical Fisheries Tech. Conf. Proceedings. 14 pages. 13

Shepherd, J.G. and D.J. Garrod (1980). "Modelling the response of a fishing fleet to changing circumstances, using cautious non-linear optimization." J. Cons. int. Explor. Mer. Vol. 39, pp. 231-238. 13

Smith, C. and R. McKelbey (1986). "Specialist and generalists: roles for coping with variability." NAJFM, 6:88-99. 14

Squires, Dale (1987). "Public regulation and the structure of production in multiproduct industries: an application to the New England otter trawl industry." Rand Journal of Economics, Vol. 18, No. 2, Summer. 15

Squires, Dale. "Production technology, costs, and multiproduct industry structure: an application of the long-run profit function to the New England fishing industry." Canadian Journal of Economics, in press, 1987. 15

Stollery, K.R. (1987). "Monopsony processing in an open-access fishery." Marine Resource Economics, 3(4):331-351. 15

Sutinen, J.G. (1986). "Seasonality in renewable resource models." Presented at the annual meeting of the Allied Social Science Association, New Orleans, La., Dec., pp. 28-31. 16

Tettey, E.O. (1983). "The Gulf of Mexico shrimp fishery: an econometric analysis of real net investment in fishing vessels." Dissertation, Department of Agricultural Economics, Texas A&M University, College Station. 140 pages. 16

Tettey, E.O., and W.L. Griffin (1984). "Investment in Gulf of Mexico shrimp vessels, 1965-77." Marine Fisheries Review, 46(2):49-52 16

Tettey, E.O., W.L. Griffin, and J.B. Penson ( ). " Real net investment in Gulf shrimp fishing vessels." Technical article, Texas Agricultural Experiment Station, Department of Agricultural Economics, Texas A&M University, College Station. 18 pages. 17

Tettey, E.O., W.L. Griffin, J.B. Penson, and J.R. Stoll (1986). "Implications of tax policy on investment in a common property resource." North American Journal of Fisheries Management, 6:100-104. 17

Thompson, R.G., M.D. George, R.J. Callen, and L.C. Wolken (1973). "A stockastic investment model for a survival conscious firm applied to shrimp fishing." Applied Economics, 5:75-87. 18

Townsend, R.E. (1985). "On "capital - stuffing" in regulated fisheries." Land Economics, 61(2):195-197. 18

Townsend, R.E. (1987). "Empirical evidence on limited entry: a survey." Draft report, Department of Economics, University of Maine, Orono, Me. 18

Wang, D.H. and Christopher B. Kellog (1986). "American lobster demand and choice of sizes in the United States." Mimeo. NOAA/NMFS, Northeast Region Analytical Services Branch, Gloucester, MA 01913-1109 19

Theoretical Qualitative Response Modelling

Aldrich, John H. and Forrest D. Nelson (1984). Linear probability, logit, and probit models. Sage University Papers, Quantitative Applications in the Social Sciences, Series/Number 07-045, Sage Publications, Beverly Hills. 19

Amemiya, T., (1978). "The estimation of a simultaneous equation generalized probit model." Econometrica, 46(5):1193-1205. 20

Amemiya, T., (1981). "Qualitative response models: a survey." Journal of Economic Literature 19(December):1483-1536. 20

Cramer, J.A. (1986). Econometric applications of Maximum Likelihood methods. Cambridge University Press. 20

Judge, G.G., W.E. Griffiths, R.C. Hill, and T. Lee (1980). The theory and practice of econometrics. John Wiley and Sons, New York, pp. 583-622. 21

Judge, G.G., W.E. Griffiths, R.C. Hill, H. Lutkepohl, and T. Lee (1985). The theory and practice of econometrics, second edition. John Wiley and Sons, New York, pp. 752-796. 21

Judge, G.G., R.C. Hill, W.E. Griffiths, H. Lutkepohl, and T. Lee (1982). Introduction to the theory and practice of Econometrics. John Wiley and Sons, New York, pp. 517-530. 21

McFadden, D. (1974). "Conditional logit analysis of qualitative choice behavior" in P. Zarembka (ed.) Frontiers in Econometrics. Academic Press, New York, pp. 105-142. 21

McFadden, D. (1985). "Qualitative response models" in W. Hildenbrand (ed.) Advances in Econometrics. Invited papers for the Fourth World Congress of the Econometric Society at Aix-En-Provence, Sept., 1980. Cambridge University Press. pp. 1-37. 21

Maddala, G.S. (1983). Limited-dependent and qualitative variables in econometrics. Cambridge University Press. 22

Applied Qualitative Response Models

Bartel, A. (1979). "The migration decision: what role does job mobility play?" Amer. Econ. Rev., Dec., pp.775-86. 22

Bell, Frederick W. and Vernon R. Leeworthy (1987). "Economic demand for marinas and projected impact on wetlands." Land Economics 63(1):79-91. 22

Berkson, J. (1944). "Application of the logistic function to bio-assay." Journal of the American Statistical Association, Vol. 39, pp. 357-356. 23

McFadden, D. (1978). "Modeling the choice of residential location." in Spatial interaction theory and residential location. Edited by A. Karlqvist, it al. Amsterdam: North-Holland, pp. 75-96. 27

McKelvey, R.D. and W. Zavoina (1975). "A statistical model for the analysis of ordinal level dependent variables." Journal of Mathematical Sociology, 4:103-120. 27

Ostrom, C.W., Jr. and J.H. Aldrich (1978). "The relationship between size and stability in the major power international system." American Journal of Political Science, 22(4):743-771. 27

Parks, R.W. (1977). "Determination of scrapping rate for postwar vintage automobiles." Econometrica, July, pp. 1099-1116. 27

Parks, R.W. (1980). "On the estimation of multinomial logit models from relative frequency data." J. Econometrics, Aug., pp. 293-304. 28

Pencavel, J.H. (1979). "Market work decisions and unemployment of husbands and wives in the Seattle and Denver income maintenance experiments." Mimeographed. April. 28

Perloff, J.M. and M.L. Wachter (1979). "The new jobs tax credit: an evaluation of the 1977-78 wage subsidy program." Amer. Econ. Rev., May, pp. 173-79. 28

Powers, J.A., L.C. Marsh, R.R. Huckfeldt, et. al. (1978). "A comparison of logit, probit and discriminant analysis in predicting family size." Amer. Statist. Assoc. proceedings of the Soc. Statist. Section, Aug., pp. 693-97. 29

Silberman, J.I. and G.C. Durden (1976). "Determining legislative preferences on the minimum ware: an economic approach." J. Polit. Econ., April, pp. 317-29. 29

Spector, L.C. (1976). "The effectiveness of a personalized system of instruction in economics." J. Personalized Instruction. Vol 1, No. 2. 29

Spector, L.C. and M. Mazzeo (1980). " Probit analysis and economic education". Journal of Economic Education, pp. 37-44. 30

Theil, H. (1971). Principles of Econometrics. New York: Wiley. 30

Uhler, R.S. (1968). "The demand for housing: an inverse probability approach." rev. Econ. Statist., Feb., pp. 129-34. 30

Weisberg, H.F. (1978). "Evaluating theories of Congressional roll-call voting." American Journal of Political Science, 22(3):554-577. 30

Wilensky, G.R. and L.F. Rossiter (1978). "OLS and Logit estimation in a physician location study." Amer. Statis. Assoc. Proceedings of the Soc. Statist. Section. Aug., pp. 260-265. 31

Wu, D.M. (1965). "An empirical analysis of household durable goods expenditure." Econometrica, Oct., pp. 761-80. 31

Shrimp Biology

Brunenmeister, S.L. (1984). "Standardization of fishing effort and production models for brown, white and pink shrimp stocks fished in U.S. waters of the Gulf of Mexico." In J.A. Gulland and B.J. Rothschild (eds.) Penaeid shrimps - their biology and management. Fishing News Books Limited, Farnham, England. Pages 187-211. 31

Carothers, P.E. and W.E. Grant (1987). "Fishery management implications of recruitment seasonality: simulation of the Texas fishery for the brown shrimp, penaeus aztecus." Ecological Modeling, 36:239-268. 32

Nichols, S., A. Shah, and G. Pellegrin, Jr. (1987). "Estimates of annual shrimp fleet bycatch for thirteen finfish species in the offshore waters of the Gulf of Mexico." Draft report. NMFS, SEFC, Mississippi Lab., Pascagoula Facility. 32

Rothschild, B.J. and S.L. Brunenmeister (1984). "The dynamics and management of shrimp in the northern Gulf of Mexico." In J.A. Gulland and B.J. Rothschild (eds.) Penaeid shrimps - their biology and management. Fishing News Books Limited, Farnham, England. Pages 145-172. 32

Introduction

In common property resources such as the Gulf of Mexico shrimp fishery changes in economic and biological conditions affect the level of fishing effort applied by fishermen. Since effort is maintained at that level where total costs are equal to total revenue at the margin, any increase in price or decrease in costs will result in an expansion of effort until the normal economic profits are dissipated. Effort levels can expand either as short or long run effects. In the short run, the variable factors of production such as crew size, days fished, or the amount or type of gear used can be altered to fit the new economic or biological conditions. In the long run, the fixed factors of production such as vessel length, hull material, or engine horsepower can be adjusted. Vessel entry and exit behavior in the fishing fleet is caused by these long run adjustments in fishing effort.

In an effort to better understand the causes of fleet size and structural change, a multidiscipline approach has been used in this technical report. Sections on economic theory, fisheries biology, statistical methodologies, and examples of their applications that relate to vessel entry and exit behavior have been incorporated in this report. For example, the probability that a given vessel would enter or exit the shrimp fishery would be a function of exvessel prices, input costs, and shrimp resource availability. To determine this probability would require the use of discrete choice modelling techniques in conjunction with the economic theories of production and fisheries as well as fisheries biology. It is hoped that the research summarized in this report will be of use to other researchers in this and related areas.

Economics

Alvarey, J., C.O. Andrew, and F.J. Prochaska (1976).
"Dual structure equilibrium in the Florida shrimp processing industry."
Fishery Bulletin. 74(4):879-883.

Stability, entry, exit, and mobility patterns for six size categories of firms in the Florida shrimp processing industry for the 1959-71 time period were analyzed using a Markov Chain technique. Forecasts over time predict that a structural equilibrium in the industry will be achieved by 1985. The forecasted changes in firm distribution suggest that Florida shrimp industry sales will become increasingly concentrated due to expansion in the number of both small and large firms. A dual equilibrium resulting in fewer medium size firms and more small and large firms can be explained by the tendency for small firms to develop a specialty product and/or services to differentiate their markets from those of the very large firm. Medium size firms, then, tend to expand or decline in size moving toward specialty products and services or exiting from the industry.

Entry into the Florida shrimp processing industry is relatively easy for small firms and more difficult for large firms. All firms are likely to increase in size by one size category per time period. Exit from the industry in one time period is less probable for small and large firms than for medium size firms. Large firms are most likely to maintain their size between any two time periods and also experience less probability of declining in size than do medium and small size firms.

Bainton, B., J. Cantena, and D. Allen (1987).
"Matching capital to resources." Prepared by Atlantic Offshore Fishermen's Association, Saltonstall - Kennedy Grant #NA86AA-H-SK131, NMFS, NOAA, USDOC

Recognizing that the nation's fisheries represent a portfolio of investment opportunities helps in developing a portfolio of management tools best suited to manage individual fisheries as well as the entire portfolio of fisheries. The major criticism of limited entry schemes is that they have been proposed as a simple fix to a complex problem. Only by understanding how a management policy fits into the business environment can its potential for success be evaluated. If fisheries are thought of as a resource portfolio, then only a portfolio approach to management can be successful.

The real question is how can fishermen be given a property right in the fishery so that they will manage the stock themselves. Individual quotas are one approach to transferring the property right to the fisherman, however, other alternatives under the limited entry heading fail to create the proper economic incentives for fishermen to properly invest in the resource. Which economic incentives are best for each fishery depend on the type of fishery and the fishermen who operate in them (fixed gear vs. troll, single or multiple species harvest operations, respectively).

Berck, P. and J.M. Perloff (1982).
"An open-access fishery with rational expectations." Working Paper 187, Division of Agricultural Sciences, University of California, California Agricultural Experiment Station, Giannine Foundation of Agricultural Economics, Dec.

Dynamic fisheries theory assumes vessel entry and exit behavior is proportional to current profits. Berck and Perloff assume that potential entrants base their decision on an estimate of all future quasi-rents (profits). In their standard model, potential entrants base their entry decision on the present value of profits where current profits are a myopic estimate of future profits. Entry, therefore, is proportional to instantaneous profits. In the rational expectations model with perfect foresight, the entry decision is based on the present value of the future quasi rents. Entry is proportional to the expected present value of the quasi rents.

This approach could account for the reluctance of vessels to exit the fishery as current profit levels decline in a particular time period; asymmetric entry and exit behavior. Firms would be more likely to enter in above average years based on the standard model, but less likely to exit the fishery during below average years.

Bjorndal, Trond and Jon M. Conrad (1987).
"Capital dynamics in the North Sea herring fishery." Marine Resource Economics, 4, pp. 63-74.

A discrete time model is formulated to model decisions of boats to enter or exit the North Sea herring fishery. A lagged model is specified to reflect adjustment time to changes in profits. The empirical results indicate that fleet adjustment in this fishery primarily depends on current period profits and that the opportunity cost may depend on returns in the alternative fishery (mackerel). Lagged variables reflecting vessel construction time accounted for a small increase in the statistical fit. The hypothesis that entry in response to positive profits is more elastic than exit due to negative profits was not supported by the results.

The harvesting industry's capital investment model was relatively simplistic reflecting the limited data set available to the authors. The annual data covered a relatively short period of time and probably little cross sectional data existed for this fishery. These limitations restrict the available degrees of freedom necessary to construct and estimated more sophisticated models.

Bjorndal, Trond and Jon M. Conrad (1987).
"The dynamics of an open access fishery." Canadian Journal of Economics, 20(1):74-85.

Bjornal and Conrad examine the open access herring fishery of the North Sea using data from the period 1963 - 1977 with a discrete time, nonlinear, deterministic model. The results of the analysis of alternative production functions for the Norwegian purse seine fishery show that the fish stock was saved from possible extinction when the EEC and Norway agreed to close down the fishery.

Blomo, V.J., J.P. Nichols, W.L. Griffing, and W.E. Grant (1982).
"Dynamic modeling of the eastern Gulf of Mexico shrimp fishery."
American Agricultural Economics Association, August, 475-482.

The impact of alternative management schemes on the shrimp fishery of the eastern Gulf of Mexico is analyzed and compared to a baseline using simulation techniques.

The fishery's biological and economic functions are modelled including intraseasonal shrimp growth rates, differences in demand for shrimp by size, and a heterogenous fishing fleet. Using consumer and producer surplus techniques, new fishing regulations appear socially optimal compared to the baseline. A rent maximization scheme increases social surplus to its highest level. However, applying such a scheme to one part of the total Gulf of Mexico shrimp fishery is not recommended.

Blomo, V., K. Stokes, W. Griffin, W. Grant, and J. Nichols (1978). "Bioeconomic modeling of the Gulf shrimp fishery: an application to Galveston Bay and adjacent offshore areas." Southern Journal of Agricultural Economics, July, 119-125.

This article incorporates a nonlinear optimization procedure into the simulation model developed by Grant and Griffin (1979). The simulation model which integrates the biological relationships among the shrimp biomass and shrimp fleet characteristics is combined with economic theory into a 12 month analysis that maximizes net income to the industry (gross returns over costs) over a shrimping season. The analysis can also evaluate changes in several institutional parameters which affect the utilization of the common property shrimp resource.

Bockstael, N.E. (1976). Analysis of investment behavior and price determination: analytical input for the formation of policy in the fisheries. Dissertation, Department of Resource Economics, URI, Kingston, RI.

A theoretical based, analytical model was developed to provide information for policy decisions about foreign fishing within the U.S. extended fisheries zone. One part of the model was the development of a disaggregate firm investment behavior model for the groundfish fishery in a dynamic modelling approach. This approach used logit estimation techniques and was particularly useful in its applicability to the shrimp vessel entry - exit decision model being formulated for the Gulf of Mexico fishery. The second part of the model explained the interaction of consumer demand, imports and domestic landings in determining ex-vessel groundfish prices to domestic fishermen and retail prices of various groundfish products.

Bockstael, N.E. and J.J. Opaluch (1983). "Discrete modelling of supply response under uncertainty: the case of the fishery." Journal of Environmental Economics and Management, 10:125-137.

In the absence of complete control in a regulated industry, effective management requires prediction of firms' behavioral responses to public policy. This paper develops a discrete choice model of supply response under uncertainty and applies it to fishery choice problems of New England fishing firms. While fishermen demonstrate a bias towards remaining within the same fishery, sufficient incentives, in terms of changes in expected returns and risk, are shown to elicit response. Due to extreme uncertainty concerning population dynamics of fish stocks, a satisficing approach to management, facilitated by this type of modelling, may be more appropriate than bioeconomic optimization.

Clark, C.W. (1976).
Mathematical Bioeconomics. John Wiley and Sons, New York.

Introduction to the mathematical theory of the conservation of renewable, natural resources primarily fish but with applications to forestry using dynamic optimization theory.

Clark, C.W. (1985).
Bioeconomic modelling and fisheries management. John Wiley and Sons, New York.

The management of commercial marine fisheries and the relationship between the economic forces affecting the fishing industry and the biological factors that determine the production and supply of fish in the sea. Primarily a presentation of the various mathematical models that are supposed to be used in fisheries management. Very helpful in developing the models of seasonality and fleet size in a mathematical framework and preparing hypotheses to test statistically.

Clark, C.W., F.H. Clarke, and G.R. Munro (1979).
"The optimal exploitation of renewable resource stocks: problems of irreversible investment." Econometrica, 47(1):25-47.

The optimal level of capital investment in the fishery is modelled based on the assumptions of a single stock of fish represented by a general production (Schaefer) model and a sole owner of the resource. This model determined the effect on the optimal path of investment and effort of new investment in the fleet and disinvestment and depreciation of the existing fishing fleet. While the long run optimal sustained yield is demonstrated to be unaffected by the assumption of irreversibility of investment, the short term dynamic behavior of an optimal exploitation policy for renewable resources may depend significantly upon the assumption.

Clark, Jerry E. and Richard S. Johnston (1986).
"Open access, market structure, optimality, and entrepreneurship in the fishery." Mimeo. Copies from Department of Agricultural and Resource Economics, Oregon State University, Corvallis, Or.

The authors discuss the issue and operating definitions of optimality of open access fisheries from the economic, biological, and policy (political) perspectives. Their study is illustrated with material from the Columbia River salmon fishery. Their conclusions are that fisheries management or fishery business decision-making should not be left to those who do not have a capital investment in the business; scientists and government officials are removed from direct involvement in the fishery and probably should not be formulating regulations. The authors argue that the competitive process is the means by which decisions are made in a capitalist system and U.S. fisheries management is nearly devoid of understanding or appreciation of this process. It is recommended that economists work with political scientists and biologists to obtain an understanding of the human and nonhuman decision making systems in the fishing business.

Grant, W.E. and W.L. Griffin (1979).
"A bioeconomic model of the Gulf of Mexico shrimp fishery." Transactions of the American Fisheries Society, 108(1):1-13.

A bioeconomic model of the brown shrimp fishery in Galveston Bay, Texas and adjacent offshore waters accurately predicts the general trends in the seasonality of shrimp harvest and the distribution of the harvest in relation to size of shrimp and water depth.

Grant, W.E., K.G. Isakson, and W.L. Griffin (1981).
"A general bioeconomic simulation model for annual crop marine fisheries." Ecological Modelling, 13:195-219.

A generalized bioeconomic simulation model of annual crop marine fisheries is described and its use in marine fisheries management is demonstrated. The biological submodel represents the recruitment of new organisms into the fishery, the movement of organisms from one fishing area to another and from one depth to another, the growth of organisms and the mortality of organisms resulting both from natural causes and from fishing. The economic submodel represents the fishing effort exerted on each resource species, the monetary costs of fishing, the value of the harvest and the rent (or excess profits) to the fishery.

Basic dynamics of the model result from changes in the number of organisms in the fishery over time, which can be summarized as a set of difference equations of the general form

$$CN/Ct = R + I - E - M - F$$

where CN/Ct is the net change in number of organisms in the fishery over time (t), R is recruitment, I is immigration, E is emigration, M is natural mortality, and F is fishing mortality. The driving variable is R whereas I, E, M, and F are functions of the state of the system at any given point in time. The model can be run in a deterministic or stochastic mode. Values for parameters affecting rates of recruitment, movement, growth, natural mortality and fishing mortality can be selected from uniform, triangular or normal distributions.

Use of the model within a fisheries management framework is demonstrated by evaluating several management alternatives for the pink shrimp fishery on the Tortugas grounds in the Gulf of Mexico. Steps involved in use of the model, including parameterization, validation, sensitivity analysis and stochastic simulations of management policies are explained.

Griffin, W., J. Warren, J. Nichols, W. Grant, and C. Pardy (1983).
"The Texas shrimp fishery: analysis of six management alternatives using the general bioeconomic fishery simulation model (GBFSM)."
TAMU-SG-84-202, Sea Grant College Program, Texas A&M University, College Station Texas, Oct., 66 pages.

Six management alternatives were evaluated in terms of their impact on total landings, amount of discards, cost and returns, and fishing effort employed. Management alternatives consisted of closure of specified areas for particular periods of time, changes in count size regulations, or both. The analyses were conducted using the General Bioeconomic Fishery Simulation Model designed to represent the important biological and economic processes of the Texas shrimp fishery. Impacts were estimated both for the first year and for a long run situation, which gave the industry time to adjust by increasing or decreasing the number of bay boats and Gulf vessels.

Hilborn, R. (1985).
"Fleet dynamics and individual variation: why some people catch more fish than others." **Can. J. Fish. Aquat. Sci.** **42:2-13.**

Most fisheries problems arise from a failure to understand and manage fishermen, and that the study of fishermen should be a major part of fisheries research. The dynamic behavior of fishing fleets can be broken into four components: investment, movement,

catching power, and discarding. The literature in each area is reviewed and the needed research is described. The second part of the paper examines the causes and consequences of individual variation in catch in a commercial purse seine fishery and a recreational hook and line fishery. It is shown that the catch is highly concentrated in the recreational fishery with a small proportion of frequent anglers catching a large proportion of the fish. Catch is more equitably distributed in the purse seine fishery. The consequences of individual variation includes the observation that small annual bag limits in the sport fishery could reduce the total catch significantly while leaving most anglers unaffected and the fact that the buy back of the most successful vessels would reduce the commercial catch by relatively little.

Karpoff, J.M. (1985).
"Time, capital intensity, and the cost of fishing effort." Western Journal of Agricultural Economics, 10(2):254-258.

If the short run marginal costs of setting and retrieving a net one more time, fishing an extra day, or setting an extra pot or trap are constant, then the prediction by Anderson (1976) that entry limitations preserve a portion of the fishery's value could be invalid. A vessels optimum capital intensity depends on the length of the fishing season. The shorter the fishing season, the less time each fisherman has to utilize his capital to harvest fish, and the less total fishing effort is applied to the fishery. Since higher levels of catching power are now utilized over a shorter fishing season, they lose some of their cost advantages, and less capital intensive vessels become more cost effective. Stricter time constraints penalize more capital intensive vessels relatively heavily and create wealth transfers among classes of fishermen.

The logical extension of this line of reasoning would be that less capital intensive vessels tend to dominate fisheries that have severely limited fishing seasons. However, in practice it would appear that more capital intensive vessels appear in fisheries that are the most time restricted, e.g. the herring fisheries in the Pacific northwest. Perhaps this result occurs because of the author's use of time in a static analysis or because of the failure to consider the common property externality explicitly in his analysis.

Krauthamer, J.T., W.E. Grant, and W.L. Griffin (1984).
"Characteristics of the Texas shrimp fleet, 1979-82." Marine Fisheries Review, 46(2):53-59.

Sound management of the Texas shrimp fishery requires an understanding of the composition of the shrimp fleet and its response to changing economic conditions and regulations. This study utilized Texas Parks and Wildlife Department licensing data to quantitatively describe and evaluate the commercial fleet from 1979 to 1982. Tables representing the number of vessels in the fleet, the license (bay, bait, Gulf) or license

combinations that they maintain, the home ports of vessels, and the counties of residence of vessel owners are presented. Despite yearly fluctuations, the shrimp fleet has been increasing as have been the purchases of single and multiple licenses. Decreases in the number of vessels in the fleet for any given year resulted primarily from vessels less than 25 feet in length and vessels 55-70 feet in length leaving the fishery. The expansion of the fleet in 1981 and its relationship to 1981 fisheries legislation is discussed.

Lane, D.E. (1986).
"A partially observable model of decision making by fishermen." Working Paper 86-46. University of Ottawa, Ontario, Canada.

This paper presents an application of a partially observable Markov decision process for the intraseasonal decisions of fishing vessel operators. Throughout each fishing season independent vessel operators must decide in which zone or fishing grounds of the fishery to fish during each period to catch the most fish with the highest return to fishing effort. Fishermen's decisions are assumed to be made to maximize net operating income. The decision model incorporates the potential catch of fish, the cost of fishing effort, and the unit price of fish. Catch potential is modelled by considering the abundance of the fish stock and the catchability of the fishing technique. Abundance dynamics not directly observed are modelled as a Markov chain with a parsimonious state space representation which renders the problem practical. Dynamic decision policies are computed by the method of optimal control of the process over a finite horizon. The resultant policies are used to simulate distributions of fishermen's net operating income, fishing effort dynamics, and catch statistics. The model may be used as a decision aid in the regulation of the common property fisheries resource.

Lane, D.E. (1987)
"Investment decision making by fishermen." Working Paper 87-20, University of Ottawa, Ontario, Canada.

This paper develops and applies a model of investment decision making by fishermen. The results of the model present an accurate picture of actual investment decisions and provide valuable insights into the behavioral basis of investment decision making by fishermen. Understanding the investment decisions of fishermen has implications for planning and regulations in fisheries. Insights gained into the key factors behind fishermen's investment decisions provide the basis for the development of strategic long term policies which anticipate fishermen's behavior. The consequences will be a movement away form reactive, short-term policies which have characterized fisheries regulations to date. Individual fishermen make investment decisions in an environment which is competitive and highly variable from season to season. Extensive variability means that economic survival must be a primary consideration in the

investment decision process. In this paper fishermen's investment decisions are modelled as a probabilistic dynamic programming problem in discrete time. Fishermen are assumed to make rational decisions based on income expectations and subject to survivability conditions to maximize the net worth of the fishing enterprise at the end of a finite planning horizon. The formal analysis of the investment model is presented and the model is applied to troller fishermen of the British Columbia commercial fishing fleet.

McKelvey, R. (1983).
"The fishery in a fluctuating environment: coexistence of specialist and generalist fishing vessels in a multipurpose fleet." JEEM, 10:287-309.

McKelvey investigates the conditions underlying the entry of existing (generalist) vessels into a fishery where existing (specialist) vessels are already exploiting the stock within a fishing season. Multipurpose vessels that switch stocks as opportunities arise represent an adaptation to the fluctuating fishing environment. They trade off the efficiency derived from specialized operation for the flexibility needed to adapt to a changing biological or economic environment. The analysis indicates that the specialist fleet will become a mixed fleet as generalist vessels enter the fishery in response to increases in the value of the resource.

Meuriot, Eric (1986).
"Fishing fleet replacement: the French policy from 1945 - 1983." Marine Policy, 10(4):294-309.

Meuriot describes the French policy towards fishing fleet replacement and discusses the problems of limiting access to the French fisheries. The policy failed to curb the harvesting capacity of the fleet, and domestic and EEC fishing conflicts led the French government to focus on short-term distributional issues rather on long-term efficiency of the fishing industry.

Orth, Geoffry C. (1986).
"Fishing strategies among southeast Alaskan salmon seiners." Unpublished Master's thesis. Department of Anthropology, University of Alaska, Fairbanks, AK 99775.

Orth's study examines the success of commercial salmon seiners in southeast Alaska and the relationship of their fishing patterns to changes in resource abundance and environmental conditions. Data was collected in the summer of 1984 during fishing trips on ten vessels based in Craig, AK and interviews with the skippers of six other

vessels. A causal model was developed that accounted for some 85 percent of the daily variance in catches in this sample, and found that two strategies (hunting-"widely foraging mode", and gathering-"sit and wait mode") coexisted in the fleet, and were fashioned by the types of information used by the skipper during fishing. The skippers tended to be "economic maximizers" in selecting a location to fish based on the level of competition and local resource abundance.

Paterson, D.G. and J. Wilen (1977).
"Depletion and diplomacy: the North Pacific seal hunt." Research in Economic History, 2:81-139.

An empirical study of the impact of joint harvest of North Pacific fur seals by the U.S. in their rookeries and by Canada as a common property, open ocean resource found the herd driven to near extinction. Dynamic theories predict that the harvesting sector was on the decline and would have collapsed due to economic pressures (primarily reduced herd size and prices). This theoretical result was supported by a descriptive discussion of the economic trends in the seal industry and by the estimation of equations measuring the time rate of change in stock size and capital investment in the industry. Of particular interest was the empirical estimation and statistical significance of capital investment as a function of profits in the industry. A stable spiral was found for the industry with capital declining in the industry (exit) and stock size recovering as the dynamic system approached a steady state equilibrium.

Penson, John B., Jr., Ernest O. Tetty, and Wade L. Griffin (1987).
"An econometric analysis of net investment in Gulf shrimp fishing vessels." Technical Article No. TA-20803 of the Texas Agricultural Experiment Station, Texas A&M University.

An econometric model of annual net investment in fishing vessels in the Gulf is estimated and the sensitivity of investment decisions in the industry to fluctuations in the cost of equity and debt capital is determined for wood, fiberglass, and steel fishing vessels. An increase in the real rate of interest on debt capital from 5 to 10 percent would cause real net investment in these fishing vessels to decrease by 3.04 percent. Low interest rates would tend to increase capitalization in the Gulf shrimp fishery while stimulating investment activities in the general economy.

Prochaska, F.J. (1985).
"Shrimp mariculture and imports: effects on U.S. markets and research needs." Presented at the Miami Economics Workshop, Sept., 6 pages.

Extensive economic research has been conducted on the shrimp industry. Principal research needs remaining are analysis of individual shrimp product markets (by form and size), economics related to improved quality, restrictions on size of shrimp harvested, and limited entry. Improvements in quality and timeliness of data are necessary to accomplish these research efforts. All or most research on the shrimp industry should be done on a regional basis with formal coordination among researchers.

Prochaska, F.J. and C.M. Adams (1987).
"Analysis of U.S. shrimp prices at exvessel, wholesale, and retail market levels." Draft report, Dept. of Food and Resource Economics, University of Florida. 17 pages.

No research has previously been conducted to determine price relationships between market levels. Differential market impacts of various price determinants and restrictive policy measures such as tariffs and quotas could not be analyzed at various market levels and for other market dimensions, such as markets defined by product size classes. The goal of the research reported in this paper was to provide information on which differential impacts can be estimated. The format of the present paper is to (1) review trends in prices, margins and market shares for 21-25 and 31-40 count raw, headless shrimp, (2) determine direction of price flows and existence of asymmetric price response between exvessel, wholesale, and retail market levels, and (3) determine factors affecting prices for the two size classes at the three market levels.

Prochaska, F.J. and C.O. Andrew (1974).
"Shrimp processing in the southeast: supply problems and structural change." Southern Journal of Agricultural Economics, July:247-252.

A growing deficit in shrimp landings relative to processing needs in the southeast region of the United States has encouraged structural changes in the shrimp industry. Assuming the supply deficit does not ease, further concentration in the shrimp processing industry is expected. Success by small firms in the industry probably will result from specific market behavior, including vertical integration, horizontal integration into other seafoods, and production of specialty products. Further study (Alvarey, J., C.O. Andrew, and F.J. Prochaska, 1976) is underway to assess more fully the effects of the shrimp supply problem on the structure, conduct, and performance of the industry.

Prochaska, F.J. and J.C. Cato (1981).
"Economic conditions in the Gulf of Mexico shrimp industry: 1960 - 1981." Staff Paper 180, Food and Resource Economics Department, Institute of

Food and Agricultural Sciences, University of Florida, Gainesville. April. 19 pages.

The historical economic conditions that contributed to the severe financial conditions existing in the domestic shrimp fishery during 1980 and early 1981 such as rapidly falling consumer demand and the lower shrimp prices, increased competition from within the fishery caused by the entry of new boats and vessels, competition from foreign imports, and rapidly increasing fuel costs are reviewed in this paper. The number of boats and vessels that have entered the fishery are noted and the relationship of this entry pattern to price movements is analyzed. Prices are discussed with respect to consumer demand and imports. In addition, the possible actions that can be taken to prevent a long term reoccurring situation are presented.

Prochaska, F.J. and W.R. Keithly (1984).
"Market impacts of U.S. shrimp imports." Draft, University of Florida, Department of Agricultural Economics, Gainesville, Fl.

The domestic import demand for shrimp and world supply of shrimp to U.S. buyers is analyzed via a simultaneous equation model to determine the principle factors affecting the import market. Import price, quantity, and tax revenue effects of proposed tariffs and/or quotas are analyzed. Finally, an exvessel domestic shrimp price equation is developed to determine the effect of a set of economic factors on exvessel shrimp prices. Estimated changes in import quantities are incorporated in the model to estimate the effects of the proposed tariffs and quotas on exvessel prices.

Prochaska, F.J., M. Suazo, and W.R. Keithly (1983).
"World shrimp production trends and the U.S. import market." Tropical and Subtropical Fisheries Tech. Conf. Proceedings. 14 pages.

The paper reviews world shrimp production trends in total and by major producers, investigates U.S. shrimp supply sources and trends, analyzes the U.S. market for imported shrimp, and draws implications with respect to future conditions in the U.S. shrimp market. Of interest is an early attempt at a simultaneous equation model (Prochaska and Keithly, 1984) to determine the principle factors affecting the import market.

Shepherd, J.G. and D.J. Garrod (1980).
"Modelling the response of a fishing fleet to changing circumstances, using cautious non-linear optimization." J. Cons. int. Explor. Mer. Vol. 39, pp. 231-238.

Linear programming is unsuitable for projecting the effects of changes in the availability of fish resources on the operations of a fishing fleet because the solutions for this complicated allocation problem are inherently extreme, sparse, and ruthless whereas the real fishing industry has substantial inertia. A cautious non-linear optimization model using non-linear penalties for deviations from a reference solution and any constraints which fail to be observed, minimizes the resulting compound objective function using the conjugate gradient method. The model reproduces an actual situation when given the appropriate data and can model changes that have happened during the past few years in the UK reasonably accurately. A range of problems can be studied by varying the weight ascribed to the various terms of the objective function and in particular the effect of varying sensitivity to economic pressures may be examined.

Smith, C. and R. McKelbey (1986).
"Specialist and generalists: roles for coping with variability." NAJFM, **6:88-99.**

Smith and McKelvey extend the specialist-generalist framework to multispecies models as a means of demonstrating how society copes with stochastic variability. Specialists develop technical skills over their environment to reduce variability. Generalists maintain low switching costs to allow them to move to the fishery generating the best potential return. As fluctuating environmental and market conditions lead to increased revenue variability, the optimal fleet will consist of a mix of these vessel types.

Behavioral descriptions of actual fisheries are used to determine the validity of the authors theoretical hypotheses. Statistical tests cannot be performed because of data limitations (costs and earnings by vessel, switching behavior, and the probability distribution for the stochastic variation in revenues). The Australian prawn and rock lobster fishery vessels behaved as theory predicted with reduced stochastic variability favoring specialist vessels and phasing out rock lobster vessels. Increased variability favored generalist vessels. Also, annual variability in catch tended to affect the generalist vessels (brine trawlers) much more then specialist (freezer trawlers) in their decision to enter or remain in the prawn fishery. Territoriality also tends to support specialists by restricting the entry of generalists to the fishery (Maine Lobster on Matinicus Island is such a perimeter-defended fishery and the diver gill nets for Columbia river salmon). Market price variability supported the generalist strategy of Maymen in Shoal Harbor, N.J. However, the ability to generalize results from case studies without an actual test of the theory is restricted.

The authors conclude the generalist vessels gain from shorten seasons and catch quotas. Specialist vessels gain from limited entry programs that tend to lengthen the fishing season and allows their catch effectiveness to work to their best advantage.

Squires, Dale (1987).
"Public regulation and the structure of production in multiproduct industries: an application to the New England otter trawl industry." Rand Journal of Economics, Vol. 18, No. 2, Summer.

This article considers the problem of managing multispecies fishing industries as one of regulating the production of individual multiproduct firms. The multispecies New England otter trawl industry is examined within this framework. Empirical results derived from estimating a multiproduct profit function indicate that management consistent with the structures of multiproduct production and costs would directly regulate inputs. Little support is provided for applying the traditional bioeconomic model to the fishery studied.

Squires, Dale.
"Production technology, costs, and multiproduct industry structure: an application of the long-run profit function to the New England fishing industry." Canadian Journal of Economics, in press, 1987.

The long-run multiproduct profit function is developed to provide a more general procedure than the static minimum cost function to examine the technological and cost determinants of multiproduct industry structure and the likely form of any market equilibrium. In this approach, outputs are endogenous and the long-run equilibrium levels of quasi-fixed factors are endogenously determined. The multiproduct structure of the multispecies New England fishing industry and the likely multiproduct form of any open access equilibrium are examined.

Stollery, K.R. (1987).
"Monopsony processing in an open-access fishery." Marine Resource Economics, 3(4):331-351.

The rational expectations approach of Berck and Perloff (1982) is adapted to investigate the effects of monopsony in the processing sector on the behavior of vessel entry and exit in the competitive harvesting sector. The assumption of perfect competition in the processing and harvesting sectors of the fishing industry is replaced by assuming that the perfectly competitive harvesting sector faces a monopsonistic processing sector. The ability of the monopsonist to depress the price paid to the fishermen depends on the slope of the long run fishing supply that is a function of the ease of entry and exit in the competitive fishery. With perfect entry and exit, the monopsonist is only able to collect the resource rent in the fishery. When entry is blocked, the monopsonist can collect the monopsony rents as well from the harvesting sector.

Sutinen, J.G. (1986).
"Seasonality in renewable resource models." Presented at the annual meeting of the Allied Social Science Association, New Orleans, La., Dec., pp. 28-31.

Seasonal variation in resource availability is the major source of seasonal or cyclical variation in economic behavior and policy for most fisheries. Equilibrium output, price, and the number of firms are derived for each season, the year, and for full bioeconomic equilibrium based on a logistic growth function for the fish stock and a production function that is related to the season of the year. The number of firms depends on the profitability of the fishery relative to the other M-1 fisheries. While firm number is not determined explicitly in the model, it is directly related to quantity through the individual firms production function and should be easily determined.

Tettey, E.O. (1983).
"The Gulf of Mexico shrimp fishery: an econometric analysis of real net investment in fishing vessels." Dissertation, Department of Agricultural Economics, Texas A&M University, College Station. 140 pages.

The real net investment in fishing vessels in the Gulf of Mexico shrimp fishery is analyzed employing an econometric model. The model is simulated over a 17 year period to examine the short and intermediate run impacts of changes in such policy variables as the real rate of interest, cost of equity capital, investment tax credit and income tax on investment behavior in fishing vessels. A forecast over a 5 year period (1978 - 1982) for real net investment in fishing vessels is also developed.

Investment tax credit stimulates investment expenditure in the Gulf shrimp fishery. However, income tax exerts the greatest influence on investment decisions in the fishing industry. While both steel and wooden vessels are expected to show continuous growth from 2978 to 1982, the stock of steel vessels should grow about three times as fast as wooden ones over this period.

Tettey, E.O., and W.L. Griffin (1984)
"Investment in Gulf of Mexico shrimp vessels, 1965-77." Marine Fisheries Review, 46(2):49-52.

This study examines implications of investment patterns in the Gulf shrimp fishery. Historical trends in capital stock of vessels are estimated for 1965-77 for different types of vessels for use with landings and sales data. Specifically, annual trends in total and per vessel shrimp landings and sales are examined. Shrimp landings and sales per dollar of investment in fishing vessels are evaluated. Apparently, the perceived value of

landings per vessel increased on average at a faster rate than production costs per vessel causing excess profit to exist. This created an incentive for investments, although there may be other reasons for stimulating investment. This expansion was interrupted only by poor economic conditions, such as in 1970 and 1973-75. Although data were not available to estimate real capital stock beyond 1977, other information suggests that substantial declines (large negative real investment) occurred in 1979-80.

Tettey, E.O., W.L. Griffin, and J.B. Penson ( ).
" Real net investment in Gulf shrimp fishing vessels." Technical article, Texas Agricultural Experiment Station, Department of Agricultural Economics, Texas A&M University, College Station. 18 pages.

An econometric model of annual real net investment in fishing vessels in the Gulf is developed to determine how the cost of equity and debt capital as well as other factors affect investment decisions in this industry. The cost of capital plays an important role in influencing the investment decisions in the Gulf shrimp fishing industry. High real interest rates were found to depress real net investment in this fishery. Investment responses to changes in macroeconomic policy are greatest for steel vessels because steel vessels contribute the most to the productivity of the Gulf shrimp fishery,. Finally, while low real interest rates are desirable for stimulating investment activities in the general economy, they would add to the overcapitalization problem that currently exists in the Gulf shrimp fishing industry. This suggests that expansionary policies designed to boost the growth of the general economy may actually lead to undesirable results for the Gulf shrimp fishing industry.

Tettey, E.O., W.L. Griffin, J.B. Penson, and J.R. Stoll (1986).
"Implications of tax policy on investment in a common property resource."
North American Journal of Fisheries Management, 6:100-104.

This study employs a financial model to examine the aggregate investment expenditures for Gulf of Mexico shrimp vessels. Specifically, the impacts of tax policies - investment tax credits and income taxes - on investment decisions in the Gulf shrimp fishery are evaluated. Contractionary tax policy is an effective tool in limiting entry to the shrimp fishery and, thereby, controlling the problem of overcapitalization. Decreases in the investment tax credit rate, increases in the income tax rate, or a combination of both policies will curtail investment activities in the fishing industry. Implementation of such tax schemes should raise total revenues of vessel owners, in the long run, from what they otherwise would have been.

Thompson, R.G., M.D. George, R.J. Callen, and L.C. Wolken (1973). "A stockastic investment model for a survival conscious firm applied to shrimp fishing." Applied Economics, 5:75-87.

An operational stockastic capacity expansion model for a survival conscious firm is developed and applied to shrimp fishing in which the entrepreneur evaluates all the information known to him at the time of the decision. The results show the effect of survival on the growth in net worth of a firm making sequential and irreversible purchases of physical capital with uncertain future yields. The survival model is applied to shrimp fishing on the Texas Gulf coast and the results are compared to those of a simple model in which survival is not considered. Bankruptcy could clearly result from the use of the simple model; survival of the firm is guaranteed by use of the survival model.

Exit from the fishery may be restricted (sticky downward) because fishermen's attitudes toward risk are not symmetric with regard to favorable and unfavorable yields and prices. Low prices and small catches in fishing may be dreaded much more than high prices and large catches are desired. In the model, the firm maximizes expected net worth at the end of a finite planning period subject to the restriction that the only allowable purchases of capacity are those for which there is no chance of incurring bankruptcy. It is assumed that the firm is unwilling to assume any risk of failure. Thus the survival restriction prohibits purchases of capacity which would lead to bankruptcy during the planning period if the worse possible yields or output prices occur in the future. Survival considerations may result in modest growth of capacity of a fishing firm, even if the expected profit of additional capacity is relatively large.

Townsend, R.E. (1985). "On "capital - stuffing" in regulated fisheries." Land Economics, 61(2):195-197.

An almost uniform experience in fisheries managed by limited entry has been the increased use of capital by each firm. The increased use of capital by firms is produced by at least six different incentives: the output effect, the substitution effect, the cost of capital effect, innovation effect, cross substitution effect, and the consumption effect. Not all of these incentives are economically undesirable. The net effect of capital stuffing is ambiguous and can only be evaluated empirically.

Townsend, R.E. (1987). "Empirical evidence on limited entry: a survey." Draft report, Department of Economics, University of Maine, Orono, Me.

Based on a world wide survey of about thirty limited entry programs, seven empirical inferences are drawn. First, a strong positive correlation exists between the restrictiveness of the limited entry plan and the appearance of economic rents. Second, there is an inverse relationship between the complexity of the regulated resource and the economic success of limited entry. Third, favorable social and political institutions can make significant contributions to the success of a plan. Fourth, limited entry generates rents primarily by solving short run crowding externalities rather than by solving long run stock externalities. Fifth, weak limited entry plans - primarily moratoria on entry in mature fisheries - have tended to become a permanent and rather inefficient form of regulation rather than evolving into more efficient management. Sixth, any rents generated for the limited entrants create almost irresistible political forces to expand the number of licenses granted. Seventh, the definition of rights under a limited entry license does not end the need for government intervention in fisheries. Rather the inherent imperfections in limited entry licenses require on going adjustments to the programs. These conclusions are necessarily preliminary, because only limited ex post empirical analysis has been conducted on limited entry programs. In general, the survey suggests that the practical aspects of limited entry are not simple and deserve more attention from fisheries economists.

Wang, D.H. and Christopher B. Kellog (1986).
"American lobster demand and choice of sizes in the United States." Mimeo. NOAA/NMFS, Northeast Region Analytical Services Branch, Gloucester, MA 01913-1109

The paper describes the markets for American lobster in the United States and analyzes demand using a generalized choice model. The authors found little price elasticity for small lobsters but greater elasticity for medium and large sized lobsters.

Theoretical Qualitative Response Modelling

Aldrich, John H. and Forrest D. Nelson (1984).
Linear probability, logit, and probit models. Sage University Papers, Quantitative Applications in the Social Sciences, Series/Number 07-045, Sage Publications, Beverly Hills.

The logit and probit models that analyze dichotomous and polytomous dependent variables are developed. Although a tendency to analysis dichotomous dependent variables with ordinary least squares regression techniques has existed, the authors demonstrate that this approach is not an appropriate strategy. Probit analysis is more

ideally suited to such problems while logit ought to be the method of choice for polytomous dependent variables.

Amemiya, T., (1978).
"The estimation of a simultaneous equation generalized probit model."
Econometrica, 46(5):1193-1205.

A class of generalized least squares estimators are proposed and their asymptotic variance-covariance matrices are obtained for a simultaneous two-equation model in which one of the dependent variables is completely observed and the other is observed only to the extent of whether or not it is positive.

Amemiya, T., (1981).
"Qualitative response models: a survey." Journal of Economic Literature 19(December):1483-1536.

Qualitative response (QR) models developed between 1970 and 1981 are reviewed in this article with special attention paid to (1) the specification of a model that is consistent with economic theory and is statistically manageable, (2) the estimation of model parameters and the hypothesis tests based on those estimated parameters, and (3) the criteria to use in choosing among competing models. First, univariate dichotomous dependent variable models are developed, such as the biometric applications of insect survival (survive = 1, death = 0) as a function of insecticide dosage. Next, multinomial or multi-response models are developed for the case of choice of occupation, housing, transportation choice, etc. Lastly, multivariate models are presented where more than one discrete dependent variable exists, e.g. determination of the probability of catching a fish given the probability that one takes a recreational fishing trip $P(Y = 1X = 1)$. Since the same set of discrete data can be analyzed by many different QR models, this survey is most useful as a guide in choosing an appropriate QR model from an economic-theoretic and a statistical view point.

Cramer, J.A. (1986)
Econometric applications of Maximum Likelihood methods. Cambridge University Press.

A self contained introduction to econometric applications of maximum likelihood methods covering general features of maximum likelihood methods, linear and non-linear regression, and discrete choice models.

Judge, G.G., W.E. Griffiths, R.C. Hill, and T. Lee (1980).
The theory and practice of econometrics. John Wiley and Sons, New York, pp. 583-622.

A more involved overview of qualitative response models econometric theory than contained in Judge, et. al. (1982) including quantal response models, binary choice models, and treatment of censored and truncated samples.

Judge, G.G., W.E. Griffiths, R.C. Hill, H. Lutkepohl, and T. Lee (1985).
The theory and practice of econometrics, second edition. John Wiley and Sons, New York, pp. 752-796.

An updated and improved discussion of qualitative response models that adds simultaneous equation models to the discussion in the first edition (Judge, et. al., 1980).

Judge, G.G., R.C. Hill, W.E. Griffiths, H. Lutkepohl, and T. Lee (1982).
Introduction to the theory and practice of Econometrics. John Wiley and Sons, New York, pp. 517-530.

An introduction to the econometric theory of binary choice models when repeated observations are and are not available, the probit and logit models, and limited dependent variable models.

McFadden, D. (1974).
"Conditional logit analysis of qualitative choice behavior" in P. Zarembka (ed.) Frontiers in Econometrics. Academic Press, New York, pp. 105-142.

An introductory to conditional logit analysis of qualitative choice behavior relating economic theory to conditional logit analysis. The conditional logit estimation technique and its statistical properties are presented. An empirical application of shopping choice mode, destination and trip frequency is conducted.

McFadden, D. (1985).
"Qualitative response models" in W. Hildenbrand (ed.) Advances in Econometrics. Invited papers for the Fourth World Congress of the Econometric Society at Aix-En-Provence, Sept., 1980. Cambridge University Press. pp. 1-37.

A survey of models and methods that have been developed for the analysis of qualitative responses where categorical responses are binomial and multinomial and multinomial responses may be ordered or unordered using single-equation models, multivariate reduced form models, and simultaneous equation models.

Maddala, G.S. (1983).
Limited-dependent and qualitative variables in econometrics. Cambridge University Press.

An extensive and very complete discussion of methods for the analysis of econometric models where the dependent variable is qualitative or limited in range. Highly recommended to anyone foolish enough to get involved in this area of econometrics.

Applied Qualitative Response Models

Bartel, A. (1979).
"The migration decision: what role does job mobility play?" Amer. Econ. Rev., Dec., pp.775-86.

A univariate, dichotomous logit maximum likelihood estimator is used to analyze a joint determination of a work decision and migration instead of a multivariate model. As a result, the sum of the five estimated probabilities could exceed unity and a correlation among the five dependent variables is ignored. A multi-response model would correct both of these problems.

Bell, Frederick W. and Vernon R. Leeworthy (1987).
"Economic demand for marinas and projected impact on wetlands." Land Economics 63(1):79-91.

A theoretical framework is developed to empirically estimate marina demand within the context of submerged wetland's use. Of interest is the use by the authors of both OLS and Logit techniques to estimate the probability of using a marina based on population, per capita income, price of marina services, cost of operating a pleasure boat, etc. The authors compare the predictive power of models based on these two approaches and chose the OLS technique. OLS was shown to be a better predictor of the data set means for this sample of data than was the model developed with Logit even though it exceeded the (0,1) values of the dependent variable. Based on Aldrich and Nelson (1984), the authors choice of an estimation technique and the resulting

model was probably inappropriate since standard regression estimates seriously mis-estimates the magnitude of the effects of the independent variables, that all of the standard statistical inferences such as hypothesis tests or the construction of confidence intervals are unjustified, and that the regression estimates will be highly sensitive to the range of particular values observed for the independent variables making extrapolations or forecasts beyond the data unjustified. Individual coefficient estimates using the two techniques did differ by a factor of ten indicating that some form of estimation bias was present. As a result, management decisions concerning submerged wetland's use based on the two different models could differ radically.

Berkson, J. (1944).
"Application of the logistic function to bio-assay." Journal of the American Statistical Association, Vol. 39, ppl 357-356.

An early application of the logistic function to a mortality-drug dosage study. A comparison of the results from the logit model and those from a model using the normal curve is made. The logit model provides a simpler means of fitting a curve with the same or better estimated probabilities than the normal curve model. Since this analysis was conducted before the advent of computers, the simpler approach of fitting the logit model to a data set was an important advantage over the normal curve model.

David, J.M. and W.E. Legg (1975).
"An application of multivariate probit analysis to the demand for housing: a contribution to the improvement of the predictive performance of demand theory, preliminary results." Amer. Statist. Assoc. proceedings of the Bus. and Econ. Statist. Section, Aug., pp. 295-300.

In this ordered, multiresponse model, the dependent variable divides the price of a house into three categories. This discrete dependent variable is then made a function of the size of the household, the age of the head of the household, the income of the head, and the number of years of education of the head of the household. The multivariate probit model estimated the probability that a certain size family, etc. purchased a house in that price range. A hedonic price analysis seemed to be a better approach for this type of analysis, since the value of the house was known.

Deacon, R. and P. Shapiro (1975).
"Private preference for collective goods revealed through voting and referenda." Amer. Econ. Rev., Dec, pp. 943-55.

The voting behavior of Californians in two referendums is analyzed in this ordered, multiresponse model.

Domencich, T.A. and D. McFadden (1975).
Urban Transportation Demand. Amsterdam: North-Holland.

The utility associated with each mode of transportation (car, bus, or train) is assumed to be a function of the mode characteristics z (time and cost associated with using the mode) and the persons socio-economic characteristics w plus an additive error term e. The error term represents those mode and socio-economic characteristics that are unobservable to the analyst. The utility functions are a function of the mode characteristics or attributes z and not the specific physical entities such as bus or car or train. Instead, the utilities depend on the bundle of services that each mode provides to each individual. Any transportation mode whose time, cost, and comfort attributes can be predicted or are known can be incorporated into this model whether or not the physical entity is known.

Goldberg, L. and F.C. Nold (1980).
"Does reporting deter burglars-an empirical analysis of risk and return in crime." Rev. Econ. Statis. August, pp. 424-31.

A burglar chooses the house to rob that gives him the maximum expected return taking into account the probability of being arrested. Although mathematically identical to the biological qualitative response models, this qualitative response model was based on the economic assumption that an individual makes rational decisions to maximize He/Its/She (his) utility.

Goodman, L.A. (1975).
"A modified multiple regression approach to the analysis of dichotomous variables." Amer. Sociological Rev., Feb., pp. 28-46.

A soldiers preference for a Northern camp relative to a Southern camp is explained as a function of the race of the soldier, the region of his origin, and the present location of his camp (North or South) in a log-linear model. While log-linear differ from logit in the parameterization of the model, both parameterizations are similar and have a simple logistic form.

Gurland, J., I. Lee, and P.A. Dahm (1960).
"Polychotomous quantal response in biological assay." Biometrics, **Sept., pp. 382-98.**

This is an example of an ordered, multiresponse model in which the dependent variable (y^*) takes on three values for dead ($y = 2$), moribund ($y = 1$), and alive ($y = 0$) for insects exposed to various dosages of insecticide. Ordered models are used whenever the values taken by the discrete dependent variable correspond to the intervals within which an unobservable continuous random variable (y^*) falls.

Hausman, J.A. and D.A. Wise (1978).
"A conditional probit model for qualitative choice: discrete decisions recognizing interdependence and heterogeneous preferences."
Econometrica, **Mar., pp. 403-26.**

A three response, unordered (general) probit model, an independent logit model, and independent probit model are estimated to explain the modal choice between driving own car, sharing a ride, and riding a bus for 557 workers in Washington, D.C. Logit and independent probit give similar results both in estimation and in the forecast of the probability of using a new mode. General probit differs significantly form the other two models both in estimation and the forecast about the new mode. General probit fits best. Primarily an article about the creation of a new computer program to estimate the parameters of a model.

Hill, C.R. (1979).
"Capacities, opportunities and educational investments: the case of the high school dropout." Rev. Econ. Statist. **Feb., pp.9-20.**

A study of the probability of dropping out of high school that noted a similarity between the probit maximum likelihood and linear probability-weighted least squares estimates.

Lee, L.F. (1978).
"Unionism and wage rates: a simultaneous equations model with qualitative and limited dependent variables." Int. Econ. Rev. **June, pp. 1081-98.**

The propensity of the ith worker to join a union is a function of the difference between union (wi1) and nonunion (wi0) wages [(wi1-wi0)/wi0], a vector of characteristics of the worker, and the attributes of the industry, rather than an assumption of utility maximization. The worker joins the union ($y_i = 1$) if the estimated $y^* 0$. The normal distribution is assumed for the error term and a probit maximum likelihood estimator is used to estimate the parameters of the model.

Li, M.M. (1977).
"A logit model of home ownership." Econometrica, July, pp. 1081-98.

The probability of a family owning a home is estimated using a logit model with census data on husband-wife families from Boston and Baltimore SMSAs. The independent variables are four age dummies, three income dummies, three family size dummies, and a race dummy. This is clearly an example of a many observations per cell model where the estimators in the maximum likelihood estimation procedure would have been asymptotically efficient, consistent, and normal. Also, since age, income, and family size are continuous variables, at least within a certain range, the creation of dummy variables to represent them did not appear to be necessary.

Medoff, J.L. (1979).
"Layoffs and alternatives under trade unions in U.S. manufacturing." Amer. Econ. Rev., June, pp. 380-95.

The Amemiya-Nold modified logit Min Chi-squared estimator was applied to a study of layoff rates.

McFadden, D. (1976).
"The revealed preferences of a government bureaucracy: empirical evidence." Bell J. Econ. Manage. Sci., Spring, pp. 55-72.

Within the framework of unordered models, the inherent weakness of independent logit is that although it works well when the alternatives are dissimilar, the assumption of independent errors makes it impossible to take into account similarities among alternatives. This hypothesis of independence of irrelevant alternatives is tested by reestimating models of selection of highway routes in California using the choice set of the chosen route and one additional route randomly selected from the set of all routes. If the hypothesis is true, estimates obtained from a full set of alternatives should be close to estimates obtained by randomly eliminating some nonchosen alternatives. In most of the examples, the hypothesis of the independence from irrelevant alternatives is rejected.

McFadden, D. (1978).
"Modeling the choice of residential location." in Spatial interaction theory and residential location. Edited by A. Karlqvist, it al. Amsterdam: North-Holland, pp. 75-96.

A person chooses a community to live in and a type of dwelling to live in creating a two step estimation process; i.e. the probability of choosing a dwelling type given the choice of community. The independence from irrelevant alternatives problem is treated by McFadden's standard Generalized Extreme Value model by setting the correlations among the utilities associated with similar alternatives (%s) to a constant. A fewer number of parameters can be estimated more efficiently, but the true correlation structure may be more complex than is represented by this simple solution.

McKelvey, R.D. and W. Zavoina (1975)
"A statistical model for the analysis of ordinal level dependent variables." Journal of Mathematical Sociology, 4:103-120.

An analysis of the voting on the 1965 Medicare Bill is used to illustrate the development of an extension to the dichotomous probit model that assumes the ordinal nature of the observed dependent variable is due to methodological limitations in collecting the data that force the lumping together of various portions of the interval level variable.

Ostrom, C.W., Jr. and J.H. Aldrich (1978).
"The relationship between size and stability in the major power international system." American Journal of Political Science, 22(4):743-771.

The leading hypotheses based on operationalizations of the key concepts which are consistent with the balance of power literature, a common data set, a coherent specification of the contending hypotheses, and the use of appropriate estimation techniques are evaluated. Probit is used to estimate the probability of war, where the dependent variable is discrete (war or peace). The hypotheses tested include (1) the probability of war declines as of the number of actors increase, (2) with the appearance of a balancing actor, or (3) if the number of actors equals two. None of the hypotheses are supported by the data set.

Parks, R.W. (1977).
"Determination of scrapping rate for postwar vintage automobiles." Econometrica, July, pp. 1099-1116.

The Amemiya-Nold modified logit Min Chi-squared estimator was applied to a study of automobile scrapping rates.

Parks, R.W. (1980).
"On the estimation of multinomial logit models from relative frequency data." J. Econometrics, Aug., pp. 293-304.

The consumers choice of owning no car, one car, or more than one car was estimated using the Amemiya-Hold modified logit minimum chi-squared estimator as a function of income grouped into ten income classes.

Pencavel, J.H. (1979).
"Market work decisions and unemployment of husbands and wives in the Seattle and Denver income maintenance experiments." Mimeographed. April.

A study to determine if the working decisions of husbands and wives were affected by the Seattle and Denver income maintenance experiments found that the linear probability-least squares and the logit maximum likelihood estimates produced similar probability estimates in a model using dichotomous independent variables.

Perloff, J.M. and M.L. Wachter (1979)
"The new jobs tax credit: an evaluation of the 1977-78 wage subsidy program." Amer. Econ. Rev., May, pp. 173-79.

The 1977-1978 wage subsidy program gave tax credits for new employment, especially of unskilled and part-time labor. The effectiveness of this program was evaluated by regressing the percentage increase in employment in the i^{th} firm, y_i^*, on independent variables representing if the firm knew about the program and actively pursued it and the percentage sales increase of the firm. Since the results from this regression were unsatisfactory, the dependent variable was divided into five categories and estimated using an unordered independent logic model. Amemiya (1981) stated that if the dependent variable is distributed normally with mean x' and variance $\%^2$ and observable, it is better to regress y_i^* directly on x_i by OLS methods. However, Amemiya also states that if the dependent variable is distributed according to an unknown nonnormal distribution that depends on x_i in more complex ways than just a location shift, the procedure used in this article could give better results than the OLS procedure because the probability that y_i^* is an element of one of the five intervals could be a better measure of certain nonnormal distributions than the moments Ey_i^* and Vy_i^*.

Powers, J.A., L.C. Marsh, R.R. Huckfeldt, et. al. (1978).
"A comparison of logit, probit and discriminant analysis in predicting family size." Amer. Statist. Assoc. proceedings of the Soc. Statist. Section, Aug., pp. 693-97.

Logit correctly classified 42.22%, probit 36.41%, and discriminate analysis 33% of the sample where the dependent variable was the number of children in six integer values from 0 to 5 and the independent variables are value of the house, the income of the husband and wife, the age of the husband and wife, the size of the city, and the religion.

Silberman, J.I. and G.C. Durden (1976)
"Determining legislative preferences on the minimum ware: an economic approach." J. Polit. Econ., April, pp. 317-29.

An ordered, multiresponse probit model is developed that predicts the probability of the number of banks chartered in an SMSA based on personal income, average manufacturing wages, the ratio of nonagricultural employment to population, and the dummy variables representing different banking regulations among SMSA's. The dependent variable takes on five values reflecting the number of bank charters in an SMSA and corresponds to five intervals of an unobservable continuous random variable y^*_i distributed normally with mean x'. An ordered probit model is also used to represent the multivariate decision by legislators voting for tow minimum wage bills. The dependent variable was a zero or one representing if they voted for either or both bills and the independent variables were socio-economic characteristics of a legislator's congressional district. Since no legislator voted against both bills (a no vote against the second bill given a no vote against the first bill), an ordered probit model ranking a representative's feelings in favor of the minimum wage was correctly used to analyze the data.

Spector, L.C. (1976).
"The effectiveness of a personalized system of instruction in economics." J. Personalized Instruction. Vol 1, No. 2.

A study on the effect of computerized instruction on the grades of students taking course in economics using probit models. The probability of a grade of A increased with the use of computerized instruction as opposed to the standard lecture method.

Spector, L.C. and M. Mazzeo (1980).
" Probit analysis and economic education". Journal of Economic Education, pp. 37-44.

The OLS methodology is inappropriate when the dependent variable is discrete because the variance of the estimated parameters is no longer constant. Probit analysis is proposed and used in an analysis of students grades on the TUCE exam with and without computerized instruction. The effect of innovative instructional techniques may not be long lasting and extends the results found by Spector (1976). A comparison of probit to OLS results indicates that probit models provide better results in that insignificant variables are not reported as significant.

Theil, H. (1971).
Principles of Econometrics. New York: Wiley.

A logit model is estimated that explains whether a firm increases or decreases its production rate once its orders and inventories are known using a minimum Chi-squared estimator.

Uhler, R.S. (1968).
"The demand for housing: an inverse probability approach." rev. Econ. Statist., Feb., pp. 129-34.

The housing price is divided into six classes in this unordered model and the probability that the price falls into one of the classes is analyzed by a multi-response quadratic discriminate analysis model assuming different variances. Multinomial logit would have been a better approach (Powers, J.A., L.C. Marsh, R.R. Huckfeldt, et. al., 1978). In addition, OLS methods could have been used since the continuous dependent variable was known and observable, unless the dependent variable was characterized by an unknown, nonnormal distribution (Amemiya, 1981).

Weisberg, H.F. (1978).
"Evaluating theories of Congressional roll-call voting." American Journal of Political Science, 22(3):554-577.

When various theories of behavior, in this case roll-call voting, have equal success in predicting observed behavior, determining the adequacy of a theory becomes difficult. The statistical criteria suggested to resolve this problem include statistical fit and comparisons to naive and simple models (based on party affiliation). The nonstatistical

criteria suggests that the theory should be similar to the process (voting behavior) it is suppose to represent. Statistical results indicate correlation and theory provides the causation, but statistical fit alone is insufficient to accept or reject a theory.

Wilensky, G.R. and L.F. Rossiter (1978).
"OLS and Logit estimation in a physician location study." Amer. Statis. Assoc. Proceedings of the Soc. Statist. Section. Aug., pp. 260-265.

A study of the probability that a Michigan trained physician would remain in Michigan found a similarity between logit maximum likelihood and the linear probability-least squares estimates.

Wu, D.M. (1965).
"An empirical analysis of household durable goods expenditure."
Econometrica, Oct., pp. 761-80.

Following the dynamic stock adjustment hypothesis, rather than utility maximization, the ith person's propensity to purchase a durable good in year t is :

$$yit = s^{*}it - si,t-1 + dit - eit$$

where s* is the desired stock, s is the actual stock, d is depreciation, e is a uniformly distributed error term, and yit = 1 if y* 0. The uniform distribution for the error term implies a linear probability model that can be estimated with ordinary least squares.

Shrimp Biology

Brunenmeister, S.L. (1984).
"Standardization of fishing effort and production models for brown, white and pink shrimp stocks fished in U.S. waters of the Gulf of Mexico." In J.A. Gulland and B.J. Rothschild (eds.) Penaeid shrimps - their biology and management. Fishing News Books Limited, Farnham, England. Pages 187-211.

Standardized fishing effort estimates pertaining to the offshore fishery on brown shrimp, white shrimp, and pink shrimp in the Gulf of Mexico from 1965 to 1980 were developed from multiple regression models. These models predicted catch-per-unit effort (CPUE) of individual vessels fishing each shrimp species within years based on

month, area, depth, bycatch of other shrimp species, and composite vessel characteristics variables. Month effects were most prominent reflecting the seasonal nature of the fisheries; in general, vessel characteristics were less important than seasonal, areal and bycatch variables concerning within year variation in CPUE. Seasonal variation in effort and CPUE pertaining to each shrimp species were staggered and illustrated the ecological distinction of the species and the annually protracted nature of the shrimp fishery. Average vessel size, net number, and horsepower of vessels fishing each shrimp species increased causing the average fishing power of vessels to increase by about 20% from 1965 to 1977.

Carothers, P.E. and W.E. Grant (1987).
"Fishery management implications of recruitment seasonality: simulation of the texas fishery for the brown shrimp, penaeus aztecus." Ecological Modeling, 36:239-268.

The relationship between recruitment seasonality and the ordering of alternative management policies for the Texas brown shrimp fishery is explored through the utilization of a general stockastic simulation model developed for annual crop marine fisheries. Although the two model specifications differ in their results depending on the assumptions concerning recruitment representation, it is clear that the temporal pattern of shrimp recruitment affects both harvest levels and catch per unit effort. No attempt was made to determine the effect of changes in seasonal stock dynamics on the spatial or temporal distribution of fishing effort (vessel investment or entry and exit behavior) during the fishing season.

Nichols, S., A. Shah, and G. Pellegrin, Jr. (1987).
"Estimates of annual shrimp fleet bycatch for thirteen finfish species in the offshore waters of the Gulf of Mexico." Draft report. NMFS, SEFC, Mississippi Lab., Pascagoula Facility.

Estimates of annual catches for thirteen species for the offshore waters of the northern and western Gulf of Mexico are made using a general linear model. The estimated bycatches for the species red snapper and King and spanish mackerel are comparable to or exceed the average recreational catches.

Rothschild, B.J. and S.L. Brunenmeister (1984).
"The dynamics and management of shrimp in the northern Gulf of Mexico." In J.A. Gulland and B.J. Rothschild (eds.) Penaeid shrimps - their biology and management. Fishing News Books Limited, Farnham, England. Pages 145-172.

An improved understanding of stock structure, stock productivity, effects of fishing on recruitment, effects of harvest size on biological production, effects of environment on reproductive success, and interactions among species will facilitate management of the Gulf of Mexico shrimp fishery. Technological improvements in fishing vessels and gear and increases in the number of craft have led to increased fishing pressure on the stocks. Current high levels of fishing effort which are at the transition point between parabolic and nonparabolic production functions estimated for each shrimp species suggest careful monitoring of the stocks is necessary and that reductions in effort would almost certainly lead to overall economic benefits, given the potential of limited returns with increasing effort and risk of sharp declines in the stock. While there is some support for the hypothesis that environmental variables control recruitment and not stock size, a correlation between stock and recruitment is demonstrable for brown shrimp. Such a correlation may also obtain for white shrimp suggesting again that increases in fishing effort should be viewed with caution. While catch and some effort statistics are available for the offshore fishery, little data exists on the important recreational and commercial inshore fisheries. Such gaps along with incompletely understood recruitment phenomena affect management advice and the success of intended management measures. This situation and the lack of current statistics creates problems in developing timely management strategies.